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From the INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

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NOTIFICATION OF TRANSMITTAL OF
THE INTERNATIONAL PRELIMINARY
EXAMINATION REPORT
(PCT Rule 71.1)

Date of mailing (day/month/year) 08.10.2004

Applicant's or agent's file reference
P014200WO MJH

IMPORTANT NOTIFICATION

International application No. PCT/GB 03/02379	International filing date (day/month/year) 30.05.2003	Priority date (day/month/year) 16.07.2002
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Applicant
UNIVERSITY OF SOUTHAMPTON et al.

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.
2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.
3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.
4. **REMINDER**

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices) (Article 39(1)) (see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

The applicant's attention is drawn to Article 33(5), which provides that the criteria of novelty, inventive step and industrial applicability described in Article 33(2) to (4) merely serve the purposes of international preliminary examination and that "any Contracting State may apply additional or different criteria for the purposes of deciding whether, in that State, the claimed inventions is patentable or not" (see also Article 27(5)). Such additional criteria may relate, for example, to exemptions from patentability, requirements for enabling disclosure, clarity and support for the claims.

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PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT (PCT Article 36 and Rule 70)



Applicant's or agent's file reference P014200WO MJH	FOR FURTHER ACTION See Notification of Transmittal of International Preliminary Examination Report (Form PCT/PEA/416)	
International application No. PCT/GB 03/02379	International filing date (day/month/year) 30.05.2003	Priority date (day/month/year) 16.07.2002
International Patent Classification (IPC) or both national classification and IPC G01V3/12		
Applicant UNIVERSITY OF SOUTHAMPTON et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.
2. This REPORT consists of a total of 6 sheets, including this cover sheet.

☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

 These annexes consist of a total of 7 sheets.

3. This report contains indications relating to the following items:
- I ☒ Basis of the opinion
 - II ☐ Priority
 - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
 - IV ☐ Lack of unity of invention
 - V ☒ Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
 - VI ☐ Certain documents cited
 - VII ☐ Certain defects in the international application
 - VIII ☐ Certain observations on the international application

Date of submission of the demand 27.01.2004	Date of completion of this report 08.10.2004
Name and mailing address of the international preliminary examining authority:  European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized Officer Schneiderbauer, K Telephone No. +49 89 2399-7613 

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT**

International application No. PCT/GB 03/02379

I. Basis of the report

1. With regard to the **elements** of the international application (*Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17)*):

Description, Pages

1-48 as originally filed

Claims, Numbers

1-30 received on 06.09.2004 with letter of 06.09.2004

Drawings, Sheets

1/10-10/10 as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
☐ the language of publication of the international application (under Rule 48.3(b)).
☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
☐ filed together with the international application in computer readable form.
☐ furnished subsequently to this Authority in written form.
☐ furnished subsequently to this Authority in computer readable form.
☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
☐ the claims, Nos.:
☐ the drawings, sheets:

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT**

International application No. **PCT/GB 03/02379**

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)).

(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes: Claims	1-30
	No: Claims	
Inventive step (IS)	Yes: Claims	1-30
	No: Claims	
Industrial applicability (IA)	Yes: Claims	1-30
	No: Claims	

2. Citations and explanations

see separate sheet

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT - SEPARATE SHEET**

International application No. PCT/GB 03/02379

1.) Reference is made to the following documents:

- D1: NEWMAN G.: "A STUDY OF DOWNHOLE ELECTROMAGNETIC SOURCES FOR MAPPING ENHANCED OIL RECOVERY PROCESSES" GEOPHYSICS, SOCIETY OF EXPLORATION GEOPHYSICISTS, vol. 59, no. 4, April 1994 (1994-04), pages 534-545
- D2: US 2002/079899 A1 (TABANOU JACQUES R ET AL) 27 June 2002 (2002-06-27)
- D3: CONSTABLE S C ET AL: "MARINE MAGNETOTELLURICS FOR PETROLEUM EXPLORATION PART 1: A SEA- FLOOR EQUIPMENT SYSTEM" GEOPHYSICS, SOCIETY OF EXPLORATION GEOPHYSICISTS. TULSA, US, vol. 63, no. 3, 1 May 1998 (1998-05-01), pages 816-825
- D4: EDWARDS R.N. ET AL.: "First results of the MOSES experiment: sea sediment conductivity and thickness determination, Bute Inlet, British Columbia, by magnetometric offshore electrical sounding" GEOPHYSICS, SOCIETY OF EXPLORATION GEOPHYSICISTS, vol. 50, no. 1, January 1985 (1985-01), pages 153-160
- D5: WO 02/14906 A (REES DAVID CHRISTOPHER ; PEDERSEN HANS MAGNE (NO); EIDESMO TERJE (N) 21 February 2002 (2002-02-21)
- D6: WITHERS ET AL.: "A case study of integrated hydrocarbon exploration through basalt" GEOPHYSICS, SOCIETY OF EXPLORATION GEOPHYSICISTS, vol. 59, no. 11, 1 November 1994 (1994-11-01), pages 1666-1679
- D7: KELLET R ET AL: "THE EFFECTS OF SOURCE POLARIZATION IN CSAMT DATA OVER TWO MASSIVE SULFIDE DEPOSITS IN AUSTRALIA" GEOPHYSICS, SOCIETY OF EXPLORATION GEOPHYSICISTS. TULSA, US, vol. 58, no. 12, 1 December 1993 (1993-12-01), pages 1764-1772
- D8: URQUHART S A ET AL: "COMBINING CSAMT AND MT IN DIFFICULT EXPLORATION ENVIRONMENTS" THE LEADING EDGE, SOCIETY OF EXPLORATION GEOPHYSICISTS, US, vol. 16, no. 4, 1 April 1997 (1997-04-01), pages 383-384
- D9: US-A-3 548 299 (DUROUX JEAN ET AL) 15 December 1970 (1970-12-15)
- D10: US-A-5 905 657 (CELNIKER GEORGE WILLIAM) 18 May 1999 (1999-05-18)
- D11: US-A-4 679 174 (GELFAND VALERY A) 7 July 1987 (1987-07-07)
- D12: WO 98/11455 A (ALTAN MEHMET S ; PGS TENSOR INC (US); ROSS CHRISTOPHER P (US)) 19 March 1998 (1998-03-19)

2.) The application does not comply with **Art.6 PCT** because the **claims are not concise**. Claims 1 and 2 differ from each other in that different second survey data sets are used: resulting from a VMD source (claim 1) and from a magnetotelluric electromagnetic field (claim 2). It would have been possible to combine these two options in one single independent claim.

3.) **Technical field:** electromagnetic surveying

4.) Claims 1 - 21:

4.1) Novelty (Art.33(1),(2) PCT) and inventive step (Art.33(1),(3) PCT) of the independent claims 1 and 2:

D1 is considered to be the closest prior art document. D1 describes separately VED source and VMD source modelling of cross-well and downhole-to-surface electromagnetic surveys. D1 considers the performance of each source taken in isolation. It does not suggest that both VED and VMD should be employed together in the survey and resulting data sets directly compared with one another to determine if hydrocarbon is present. The present invention does provide for such methods which consist of the method steps as described in claims 1 and 2. These methods have the advantage of avoiding ambiguities in the results.

As none of the documents of the ISR (D1-D12) hint at such methods, the subject-matters of independent claims 1 and 2 are new and inventive.

4.2.) Dependent claims:

Claims 3-21 are dependent on claim 1 or claim 2 and do as such also meet the requirements of the PCT with respect to novelty and inventive step.

5.) Claims 22-30:

5.1) Claim 22 is unclear (Art. 6 PCT):

5.1.1) Claim 22 refers to a device (vehicle) and therefore should only be defined by structural features. A "VED source" and a "VMD source" are no structural features; these terms relate to the use of two electromagnetic sources: there are two electromagnetic sources, the one of which is suitable for being used as VED source whereas the other source is suitable for being used as VMD source. See also PCT-Guidelines (Section IV/ III/ 4.8 a).

5.1.2.) Additionally, the whole description leaves the impression that VED and VMD data have to be interpreted in a special way, which is essential for the whole invention, namely according to the method as claimed in claims 1 or 2.

5.1.3) Therefore, in order to render claim 22 clear and admissible, it has been interpreted by the examiner as a claim to a system containing

- 1.) a submersible vehicle comprising two electromagnetic sources, the one of which is suitable for being used as VED source whereas the other source is suitable for being used as VMD source and
- 2.) means in order to carry out a method as claimed in claims 1 or 2.

5.2) Novelty and inventive step (Art. 33(1),(2),(3) PCT):

The subject-matter of such a claim 22 (interpreted as mentioned in point 5.1.3) is new and inventive (see also point 4.1 of the YPER).

Consequently, also the subject-matters of the dependent claims 23-30 are new and inventive.

6.) Industrial applicability (Art.33(1),(4) PCT):

Beyond any doubt the invention, as defined in claims 1-30, is industrially applicable.

CLAIMS

1. An electromagnetic survey method for surveying an area that is thought or known to contain a subterranean hydrocarbon reservoir, comprising:
 5 obtaining a first survey data set from a vertical electric dipole (VED) source;
 and
 obtaining a second survey data set from a vertical magnetic dipole (VMD) source.
- 10 2. An electromagnetic survey method according to claim 1, wherein the VED source and the VMD source are mounted on a common submersible vehicle.
3. An electromagnetic survey method according to claim 1 or 2, wherein the first and second survey data sets are obtained together.
- 15 4. An electromagnetic survey method according to claim 1 or 2, wherein the first and second survey data sets are obtained separately.
5. An electromagnetic survey method according to any one of the preceding
 20 claims, wherein the VED and VMD sources are operated at different frequencies.
6. An electromagnetic survey method for surveying an area that is thought or known to contain a subterranean hydrocarbon reservoir, comprising:
 obtaining a first survey data set from a vertical electric dipole (VED) source;
 25 and
 obtaining a second survey data set from naturally occurring magnetotelluric (MT) electromagnetic fields.

7. A method of analysing results from an electromagnetic survey of an area that is thought or known to contain a subterranean hydrocarbon reservoir, comprising:
providing a first survey data set obtained from a vertical electric dipole (VED) source;
- 5 providing a second survey data set obtained from a vertical magnetic dipole (VMD) source;
generating a first normalisation data set specific to the first survey data set;
generating a second normalisation data set specific to the second survey data set;
- 10 combining the first survey data set and first normalisation data set to obtain a first results data set that represents a difference between the first survey data set and the first normalisation data set; and
combining the second survey data set and second normalisation data set to obtain a second results data set that represents a difference between the second survey
- 15 data set and the second normalisation data set.
8. A method of analysing results from an electromagnetic survey of an area that is thought or known to contain a subterranean hydrocarbon reservoir, comprising:
providing a first survey data set obtained from a vertical electric dipole (VED)
- 20 source;
providing a second survey data set obtained from naturally occurring magnetotelluric (MT) electromagnetic fields;
generating a first normalisation data set specific to the first survey data set;
generating a second normalisation data set specific to the second survey data
- 25 set;
combining the first survey data set and first normalisation data set to obtain a first results data set that represents a difference between the first survey data set and the first normalisation data set; and

combining the second survey data set and second normalisation data set to obtain a second results data set that represents a difference between the second survey data set and the second normalisation data set.

- 5 9. A method of analysing results from an electromagnetic survey according to claim 7 or 8, further comprising:

normalising each of the first and second survey data sets relative to the respective first and second normalisation data sets or first and second functions specific to the first and second data sets respectively.

10

10. A method of analysing results from an electromagnetic survey according to any one of claims 7 to 9, wherein the first and second normalisation data sets or functions are calculated from a rock formation model.

- 15 11. A method of analysing results from an electromagnetic survey according to any one of claims 7 to 9, wherein the first and second normalisation data sets or functions are calculated from the first and second survey data sets.

- 20 12. A method of analysing results from an electromagnetic survey according to any one of claims 7 to 10, wherein the first results data set represents the difference between the first survey data set and the first normalisation data set as a function of position within the area, and the analysis of the first results data set includes identifying a location of a boundary of the subterranean hydrocarbon reservoir.

- 25 13. A computer program product bearing machine readable instructions for implementing a method of analysing results from an electromagnetic survey according to any one of claims 7 to 12.

14. A computer apparatus loaded with machine readable instructions for implementing the method of analysing results from an electromagnetic survey according to any one of claims 7 to 12.

5 15. A method of planning an electromagnetic survey of an area that is thought or known to contain a subterranean hydrocarbon reservoir, comprising:

creating a model of the area to be surveyed including a seafloor, a rock formation containing a postulated hydrocarbon reservoir beneath the seafloor, and a body of water above the seafloor;

10 setting values for water depth, depth below the seafloor of the postulated hydrocarbon reservoir, and resistivity structure of the rock formation; and

performing a simulation of an electromagnetic survey in the model of the survey area by obtaining a first survey data set from a simulated vertical electric (VED) dipole source and a second survey data set from a simulated vertical magnetic

15 dipole (VMD) source.

16. A method of planning an electromagnetic survey of an area that is thought or known to contain a subterranean hydrocarbon reservoir, comprising:

20 creating a model of the area to be surveyed including a seafloor, a rock formation containing a postulated hydrocarbon reservoir beneath the seafloor, and a body of water above the seafloor;

setting values for water depth, depth below the seafloor of the postulated hydrocarbon reservoir, and resistivity structure of the rock formation; and

25 performing a simulation of an electromagnetic survey in the model of the survey area by obtaining a first survey data set from a simulated vertical electric (VED) dipole source and a second survey data set from simulated magnetotelluric (MT) electromagnetic fields.

17. A method of planning an electromagnetic survey according to any one of claims 15 or 16, further comprising:

repeating the simulation for a number of source-to-detector distances and frequencies in order to select optimum surveying conditions in terms of source-to-detector distance for probing the hydrocarbon reservoir.

18. A method of planning an electromagnetic survey according to any one of claims 15 to 17, wherein the model includes a body of air above the body of water, and wherein the simulation takes account of signal propagation paths including the body of air when calculating the first and second survey data sets.

19. A method of planning an electromagnetic survey according to any one of claims 15 to 17, further comprising:

normalising each of the first and second survey data sets relative to respective first and second normalisation data sets or functions specific to the first and second survey data sets respectively.

20. A computer program product bearing machine readable instructions for implementing the method of planning an electromagnetic survey according to any one of claims 15 to 19.

21. A computer apparatus loaded with machine readable instructions for implementing the method of planning an electromagnetic survey according to any one of claims 15 to 19.

22. A submersible vehicle for subsea electromagnetic surveying, comprising:
a vertical electric dipole (VED) source; and
a vertical magnetic dipole (VMD) source.

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ART 34 ANDT

23. A submersible vehicle according to claim 26, wherein the VED source and the VMD source comprise respective antennae mounted such that their dipole axes are aligned.
- 5 24. A submersible vehicle according to claim 22 or 23, further comprising at least one waveform generator operable to transform a high voltage, low current AC drive signal received from an umbilical cable into a low voltage, high current AC drive signal to drive the VMD and VED antennae.
- 10 25. A survey apparatus comprising:
a submersible vehicle according to any one of claims 22 to 24;
a signal power supply unit for generating a high voltage, low current signal power supply for the submersible vehicle; and
an umbilical cable releasably connectable at ends thereof to the signal power
15 supply unit and the submersible vehicle.
26. A survey apparatus according to claim 25, further comprising a plurality of electromagnetic signal detectors.
- 20 27. A surface vessel carrying a survey apparatus according to claim 25 or 26.
28. A static platform carrying a survey apparatus according to claim 25 or 26.
29. A well carrying a survey apparatus according to claim 25 or 26.
- 25 30. A borehole carrying a survey apparatus according to claim 25 or 26.

31. A method of analysing results from an electromagnetic survey of an area that is thought or known to contain a subterranean hydrocarbon reservoir, comprising:

providing a survey data set obtained from a vertical electric dipole (VED) source;

5 generating a normalisation data set specific to the survey data set, wherein the normalisation data set is calculated from a rock formation model; and

combining the survey data set and normalisation data set to obtain a results data set that represents a difference between the survey data set and the normalisation data set.

10

32. The method of claim 31, wherein the rock formation model includes resistivity.

33. The method of claim 31, wherein the rock formation model is derived from a
15 combination of geological data and resistivity data.

34. The method of claim 33, wherein the geological data is from seismological surveying.

20 35. The method of claim 33 or 34, wherein the resistivity data is from well logging.

36. The method of any one of claims 31 to 35, wherein the results data set represents the difference between the survey data set and the normalisation data set as
25 a function of position within the area, and the analysis of the results data set includes identifying a location of a boundary of the subterranean hydrocarbon reservoir.

37. A computer program product bearing machine readable instructions for implementing a method of analysing results from an electromagnetic survey according to any one of claims 31 to 36.

5 38. A computer apparatus loaded with machine readable instructions for implementing the method of analysing results from an electromagnetic survey according to any one of claims 31 to 36.

39. A method of planning an electromagnetic survey of an area that is thought or
10 known to contain a subterranean hydrocarbon reservoir, comprising:

creating a model of the area to be surveyed including a seafloor, a rock formation containing a postulated hydrocarbon reservoir beneath the seafloor, and a body of water above the seafloor;

15 setting values for water depth, depth below the seafloor of the postulated hydrocarbon reservoir, and resistivity structure of the rock formation; and

performing a simulation of an electromagnetic survey in the model of the survey area by obtaining a survey data set from a simulated vertical electric (VED) dipole source; and

20 adjusting the model to remove the postulated hydrocarbon reservoir and repeating the simulation to obtain a normalisation data set for comparison with the survey data set.

40. A method of planning an electromagnetic survey according to claim 39, further comprising:

25 repeating the simulation for a number of source-to-detector distances and frequencies in order to select optimum surveying conditions in terms of source-to-detector distance for probing the hydrocarbon reservoir.

41. A method of planning an electromagnetic survey according to claim 39 or 40, wherein the model includes a body of air above the body of water, and wherein the simulation takes account of signal propagation paths including the body of air when calculating the survey and normalisation data sets.

5

42. A computer program product bearing machine readable instructions for implementing the method of planning an electromagnetic survey according to any one of claims 39 to 41.

10 43. A computer apparatus loaded with machine readable instructions for implementing the method of planning an electromagnetic survey according to any one of claims 39 to 41.

15 44. A method of monitoring an area that contains a subterranean hydrocarbon reservoir by electromagnetic surveying, comprising:

obtaining a first VED survey data set of the area;

waiting a period of time;

obtaining a second VED survey data set; and

20 combining the first and second VED survey data sets to obtain a results data set that represents a difference between the first and second VED survey data sets, said difference being indicative of changes of the reservoir during said period of time.

45. The method of claim 44, wherein the first and second VED survey data sets are also combined with a normalisation data set.

25

46. The method of claim 45, wherein the normalisation data set is obtained from a survey of the area by a vertical magnetic dipole (VMD) source

47. The method of claim 45, wherein the normalisation data set is obtained from a survey of the area by naturally occurring magnetotelluric (MT) electromagnetic fields.
48. The method of claim 45, wherein the normalisation data set is calculated from
5 a rock formation model.
49. The method of any one of claims 44 to 48, wherein the period of time is at least a day, a week, or a month.
- 10 50. The method of any one of claims 44 to 49, further comprising: analysing the results data set to identify changes in boundaries of the reservoir during the period of time.
- 51., A computer program product bearing machine readable instructions for
15 implementing the method of any one of claims 44 to 50.
52. A computer apparatus loaded with machine readable instructions for implementing the method of any one of claims 44 to 50.